Attention: this version has been completed with Google Translate , it certainly contains errors or inaccuracies.

The Gemological Microscope

Name and Appearance	(**Italian** – Microscopio) (**English** – Microscope) (**French** - Microscope) (**Spanish** - Microscopio) (**Portuguese** – Microscópio) (**Thai** - กล้องจุลทรรศน์ - klong jun tharansan) (***German*** - Mikroskop) (**Arabic -** مجهر majhar) (**Russian** - микроскоп - microskop) (**Mandarin** -显微镜- xiǎ nw ē ij ì ng) (**Swahili** - darubini) (**Hindi** - माइक्रोस्कोप - maikroskop)	**Photo** 
History	The microscope has a **long and complex history** , but its application in gemology has been instrumental in identifying and characterizing gemstones. The following is a brief history of the microscope and its evolution in the gemology industry, including dates and biographies of inventors and innovators. The first microscope was probably invented in 1590 by Dutch lens makers **Hans and Zacharias Jansen .** It was a simple device which consisted of **two convex lenses in a tube** , which could magnify an object up to nine times its size. This early microscope, known as a "simple microscope", was mainly used to examine small objects such as insects and plant parts. In 1609, **Galileo Galilei also** dealt with this instrument. However, that of the Italian thinker was a device capable **of magnifying distant objects.** It consisted of a **3x telescope** , which he used to observe the mountains on the moon, the phases of Venus and the four moons of Jupiter. Galileo's telescope consisted of a cardboard tube with two glass lenses, a convex lens on the side facing the observed object, and a concave lens on the eyepiece side. Thanks to the combination of these lenses, Galileo was able to obtain a **magnification of about 30 times** . Later, in 1610, Galileo improved the design of his telescope, increasing the magnification to about **50 times** . Galileo's telescope represented a great leap forward in the history of science, as it allowed scientists to observe the sky in greater detail and accuracy, paving the way for many important astronomical discoveries. In **1665** , English scientist **Robert Hooke** published a book called " Micrographia ," which included detailed illustrations of objects he had examined **using a microscope** . This book was the first to popularize the use of microscopes and inspired many other scientists to start using them in their work. Over the next few centuries many improvements were made to the microscope. In **1674** , **Antonie van Leeuwenhoek** , a Dutch scientist, improved the microscope design **by using only one lens instead of two** . This new design, known as a "compound microscope," allowed for much greater magnification. **polarized light and dark-field illumination** were introduced . These new techniques allowed for even greater detail and precision in examining objects under a microscope. In **1834 Sir David Brewster** wrote what is probably the first scientific description of the **internal characteristics of gemstones as seen under a microscope** . Brewster also explained the benefits of immersion when studying gems with a microscope.	

	In addition, there was now the small but useful dichroscope, which, as the great gemologist **Max Bauer said** , "should be in the hands of anyone who buys or sells precious stones" One of the first gemological microscopes was the " Dunkelschön " developed by **Julius Caesar La Garde** in **1882** . This microscope used a diffuse light illumination system and was equipped with a variable magnification system. Another historical gemological microscope is the **1930 "** Hanneman -Joachim" , developed by **Robert Hanneman and Walter Joachim** . This microscope was equipped with an incident light illumination system and a rotary table for the analysis of cut gems. In the same year, a model specifically designed for the observation of gemstones and their identification was introduced by **Robert M. Shipley ,** founder of the Gemological Institute of America (GIA). **In the early 20th century** the microscope became an important tool **in the gemological industry as an essential means of identifying and characterizing gemstones** . Gemologists use microscopes to examine the internal and external characteristics of gemstones, including inclusions, fractures, and color zoning. One of the most important innovations in the use of the microscope in gemology was the introduction of the **stereomicroscope** . This microscope, first developed **in the 1920s** , uses two separate lenses to create a three-dimensional image of an object. This allows gemologists to examine the surface of a gemstone in much greater detail. In **1949** Hans Günter Schneider, in collaboration with Prof. Dr. Schlossmacher , built an improved version of the gemological microscope. In those years, the first hand-made horizontal microscopes were produced. In **1967 , the first internal stereo microscopes** were built . Another major development in the use of the microscope in gemology was the introduction of the **fiberoptic light source in the 1970s** . This technology allowed for much better illumination of the object under study, making it easier to see even the smallest details. Today gemologists use a variety of different microscopes depending on the specific needs of their work. Some of the most commonly used microscopes in gemology include the **stereo microscope , polarizing microscope, and fluorescence microscope.**
Reference scientific laws	The scientific laws of reference to the microscope include **diffraction, interference, refraction, reflection and polarization** . Among the principal discoverers of the scientific laws relating to the microscope are Ernst Abbe (1840-1905), August Köhler (1866-1948) and Max von Laue (1879-1960).
	Diffraction Diffraction is an optical phenomenon that occurs when light passes through a surface with irregularities, such as a gem with inclusions or dislocations. These irregularities deflect the light and create diffraction patterns, i.e. geometric figures that can be observed under a microscope. To measure diffraction under a microscope, a diffraction grating is used, which is a glass or plastic plate on which small holes are engraved at regular intervals. By placing the diffraction grating on the microscope stage and observing the image of the gem through it, it is possible to count the number of visible diffraction bands, which indicate the amount of irregularities present in the gem. Diffraction measurement can provide information on the purity of the gem and its geographical origin, as each geological location has specific inclusion and dislocation characteristics that generate unique diffraction patterns. **The interference** Interference is an optical phenomenon that occurs when two light waves overlap, creating interference that can be constructive or destructive. In gemology, interference occurs when light passes through a doubly refracting gem.

To measure the interference under the microscope, the dispersion cone is used, which is a transparent glass or plastic disc that has a series of colored rings representing the different intensity of the interference. The gem is placed on the microscope stage and the image is observed through the dispersion cone. Each color corresponds to a different degree of interference, and its intensity can be evaluated based on the distance of the ring from the center of the cone.

Interference measurement can provide information about the crystalline structure of the gem and its geographical origin, as each geological location has a different arrangement of molecules within the gem that generates unique interference patterns.

The Refraction

Refraction is an optical phenomenon that occurs when light passes through a medium with a refractive index other than that of air, such as a gem. In gemology, refraction is measured through the gemological microscope using the refractometer.

To measure refraction, the gem is placed on the microscope stage and the image is observed through the prism of the refractometer. The light passes through the gem and the prism, and the angle of refraction is measured using the graduated scale on the refractometer.

The measurement of refraction is essential to identify the gem and to determine its refractive index, which can provide information on its chemical composition and its geographical origin. Furthermore, refraction can be used to distinguish between natural and synthetic gemstones, as the latter often have a different refractive index than natural gemstones.

The Reflection (of light)

Reflection is an optical phenomenon that occurs when light hits a surface and is reflected back. In gemology, reflection is measured by the gemological microscope using the well-known "double reflector ".

To measure the reflection, the gem is placed on the microscope stage and the image is observed through the double reflector . The light from the microscope lamp is reflected on the gem surface and back, forming a double image. These two images can be aligned using the double reflector , allowing the angle of reflection to be measured.

Reflection measurement is essential to identify the gem and to determine its optical characteristics. In particular, reflection can be used to evaluate the quality of the gem's cut and to locate any inclusions or internal flaws. Furthermore, reflection can be used to identify the geographical origin of the gem, as some mines produce gems with specific reflection characteristics.

The Polarization

Polarization in gemology refers to the optical property of gemstones to change the polarization of light passing through them. When light passes through an anisotropic gemstone , it is polarized in two directions perpendicular to each other, producing two polarized light beams. This phenomenon is known as double refraction. The gemological microscope is an instrument that allows you to observe the polarization of light passing through a gemstone and to determine its optical character.

To measure polarization with the gemological microscope, polarized light must be used, which can be generated by using a polarizer placed over the light source of the microscope. You place the gemstone on the microscope viewing platform and rotate the polarizer to observe changes in the polarization of light as you rotate the gemstone. In this way, optical figures can be observed which indicate the optical character of the gemstone, such as single refraction, double refraction or anomalous double refraction. Polarization is therefore an important optical property of gemstones that can be observed and measured using the gemological microscope.

Usage

The main functions of the gemological microscope include the evaluation of the clarity, colouration, shape, size and structure of a gemstone. Additionally, the gemological microscope can aid in the **discovery of inclusions, scratches, fractures, and other features internal and superficial** that help in the identification of the gemstone.

Limitations

Limitations of using the gemological microscope in gem identification may include the difficulty of distinguishing between natural and man-made inclusions, the possibility that some inclusions may be hidden by heat or chemical treatments, and the need to use other analytical techniques to confirm gemstone identification.

How to use

Examining gemstones through a gemological microscope can be done in different ways depending on the objective of the analysis. Here are the general steps of examining through the various types of lighting:

Darkfield Illumination:

1. Insert the stone into the specific clamp and fix it to the base of the microscope.
2. Select the objective and darkfield illumination condition.
3. Rotate the stone to examine it from all sides and look for inclusions, fractures, or other internal features.
4. Observe the presence of optical phenomena such as the Schiller effect or the opal effect.
5. Analyze the color of the stone in this lighting condition.

Bright field illumination:

1. Insert the stone into the specific clamp and fix it to the base of the microscope.
2. Select the objective and brightfield illumination condition.
3. Rotate the stone to examine it from all sides and look for inclusions, fractures, or other internal features.
4. Analyze the color of the stone in this lighting condition.
5. Check for specific stone features, such as growth lines.

Diffused light illumination:

1. Insert the stone into the specific clamp and fix it to the base of the microscope.
2. Select the lens and diffuse light lighting condition.
3. Rotate the stone to examine it from all sides and look for inclusions, fractures, or other internal features.
4. Analyze the color of the stone in this lighting condition.
5. Check for optical phenomena such as scattering, fluorescence, or phosphorescence.

Fiber optic lighting:

1. Insert the optical fiber into the bottom of the microscope.
2. Insert the stone into the gripper on top of the microscope.
3. Select the lens and position the optical fiber so that the light is reflected on the stone.
4. Rotate the stone to examine it from all sides and look for inclusions, fractures, or other internal features.
5. Analyze the color of the stone in this lighting condition.
6. Check for optical phenomena such as scattering or fluorescence.

Polarized light illumination

1. Sample Preparation: The gemstone to be examined is mounted on a transparent stage and placed on the microscope platform. It is important that the stone is positioned so that light can pass through it easily.
2. Polarized Light Illumination: Turn on the polarized light on the microscope and adjust it to the gemstone. Polarized light is light that travels in one direction, in contrast to unpolarized light, which travels in all directions.
3. Polarized Light Viewing: Look at the gemstone through the microscope while it is illuminated in polarized light. In this way the interference figures caused by the birefringence of anisotropic stones can be observed . Anisotropic stones are stones that exhibit birefringence and double refraction.
4. Cross-polarized light illumination: Rotate the polarizing plate of the microscope 90 degrees to obtain cross-polarized light. Cross-polarized light is light that propagates in directions perpendicular to each other with respect to polarized light.

	5. Cross-Polarized Light Viewing: Look at the gemstone through the microscope while it is illuminated in cross-polarized light. In this way, extinction figures can be observed, which are dark areas of the gemstone where light does not pass through the birefringence of the stone. 6. Comparison of figures: compare the figures observed in polarized light and cross-polarized light with those present in a reference table to identify the precious stone. 7. In general, the use of polarized light and cross-polarized light in the gemological microscope allows the determination of birefringence, double refraction and the presence of inclusions or fractures within the gemstone.
Accessories	**Polarizer** : it is a polarizing filter that can be inserted between the light source and the gemstone, to create polarized light. There are also cross polarizers that you can insert into the bottom of the microscope, which help identify the birefringence of the stone. **Ultraviolet light gemological microscope** : This type of microscope allows you to see the fluorescence of gemstones. Gemstones fluoresce in various colors depending on the type of stone and the ultraviolet light source used. **Turntable** : A turntable can be useful for rotating the gemstone as you carry out your analysis. **Heating device** : this accessory can be useful for heating the gemstone before carrying out the analysis. This can make it easier to visualize some features of the stone. **Refractive Index Meter** : This device allows you to measure the refractive index of the gemstone. This can be helpful in identifying the type of stone. **Image analysis software** : There are gem microscope software available that allows you to analyze images and record information about the examination. **Camera** : A camera can be used to take pictures of gemstones for archival purposes or to share them with other gemologists. **Fiber Optic Illuminator** : This accessory allows specific parts of the gemstone to be illuminated and the internal features to be seen in more detail.
Precautions	The main precautions in using the gemological microscope include wearing safety glasses, handling gemstones gently, using adequate lighting to avoid eye strain, and cleaning the microscope regularly to avoid formation of dust or other deposits on the lens surface.
Set off	**Base** : the bottom part of the microscope that supports it. **Column** : The vertical structure that connects the base to the microscope head. **Head** : The top part of the microscope, which contains the eyepiece and objective lenses. **Eyepiece** : The lens through which the observer looks at the object under the microscope. **Objective** : The bottom lens of the microscope that magnifies the object and projects it into the eyepiece. **Focus** - the mechanisms that allow you to adjust the focus of the object. **Illumination** - The illumination system that illuminates the object and provides uniform illumination for observation. It may include a light source, condenser lens, and filter. **Object table** : The platform on which the object to be observed is placed, usually equipped with clamps to hold the object securely in place.
Unit of measure	Units of measurement used in analyzing gemstones using the microscope include the **millimeter (mm)** for size of stones, color grade, Mohs scale of hardness for assessing the hardness of stones, specific density and I refractive index for determining the nature and optical properties of gemstones.
Types	There are several types of gem microscope, including the **stereoscopic microscope, phase contrast** microscope, and **polarizing** microscope .
Famous models	There are currently several models of gemological microscopes on the market, including:

	"Leica DM2500 M": is a gemological polarizing microscope that offers a clear and detailed view of the internal structure of precious stones. It has adjustable LED lighting, an interchangeable polarizing filter system and an integrated Bertrand compensation system. The price can vary between 10,000 and 20,000 euros. " **Olympus BX51":** is another model of gemological polarizing microscope that offers high resolution images with a large depth of field. It has adjustable LED illumination, a tilt-and-rotate binocular head, and an interchangeable polarizing filter system. The price can vary between 7,000 and 12,000 euros. **"Nikon Eclipse LV100 POL":** is a gemological polarizing microscope with advanced LED illumination technology. It offers a sharp and detailed view of gemstones, with an extremely wide depth of field and high definition resolution. The price can vary between 15,000 and 25,000 euros. " **Zeiss Axioscope POL":** is a high-end gemological polarizing microscope, which offers a three-dimensional view of precious stones. It has adjustable LED lighting, an interchangeable polarizing filter system and an integrated Bertrand compensation system. The price can vary between 20,000 and 30,000 euros.	
Innovation	Over the past 10 years, the gem microscope has been improved with the addition of **digital imaging techniques,** image analysis software, and fluorescence microscopes. The X-ray microscope was also developed for analyzing the chemical composition of gemstones.	
Get curious	• One of the curiosities related to the microscope is that the **term "microscope"** was coined by **Giovanni Faber in 1625** . Furthermore, the construction of high quality microscopes still requires great craftsmanship and knowledge of glass and light techniques. • Modern **gemological microscopes are often equipped with digital cameras** and image analysis software for greater accuracy and ease of use. • The gemological microscope can be used not only for the analysis of gemstones, but also for the analysis of **industrial and biological materials** . • In the field of gemology, microscopic analysis is just one of many techniques used to identify gemstones, and is often used in conjunction with other techniques such as spectroscopy and thermoluminescence.	
Spread	The gemological microscope is used worldwide in the evaluation and identification of gemstones. It is an essential tool for gemologists, jewelry appraisers, lapidaries and mineral collectors. Major manufacturers of gemological microscopes include Leica, Zeiss, Nikon, Meiji Techno and Wild. There are also many companies that produce mid-range and low-end gemological microscopes.	